Technical White Paper
Wellhead Gas / Associated Gas Integrated Energy Utilization & Cogeneration System

1. Introduction

Driven by the global energy transition and the "Dual Carbon" strategic goals, the resource utilization of vented natural gas (including wellhead gas, associated gas, and coalbed methane) during oil and gas production has become a critical component of green mine construction. Traditional flaring or direct venting not only results in significant energy waste but also poses serious safety hazards and greenhouse gas emission issues.

Although traditional diesel generators or grid power are still widely used at oilfield sites, they face challenges such as high operating costs, high carbon emission intensity, and unstable power supply in remote areas. This is particularly true for sour gas fields (e.g., Northern Shaanxi, Sichuan-Chongqing regions) and low-pressure gas fields (e.g., Shanxi, Inner Mongolia regions), where the safe and efficient utilization of low-quality gas has always been an industry pain point.

Relying on years of profound experience in the oilfield service sector, combined with advanced gas engine technology and waste heat recovery processes, **JingTao Energy** presents the **Wellhead Gas / Associated Gas Integrated Energy Utilization System**. By adopting the "Gas-for-Oil" and "Combined Heat and Power (CHP)" models, this system achieves efficient conversion from wasted resources to electrical and thermal energy, providing core power assurance for the digital transformation and green production of oilfields.

2. Technical Challenges and Industry Needs

Fig. 2-1: Jingtao Energy CHP System - Designed to tackle the challenges of associated gas utilization.

2.1 Industry Status and Pain Points

Currently, the treatment of associated gas and wellhead gas at oil and gas fields faces the following technical and economic challenges:

- Resource Waste & Environmental Pressure: A large amount of associated gas is directly burned (flared) or vented due to high recovery costs or unstable gas volumes, resulting in methane (a potent greenhouse gas) emissions.

- Difficulty in Utilizing Sour Gas: Some wellhead gases (such as in Northern Shaanxi gas fields) have hydrogen sulfide (H_2S) content exceeding 6000ppm, making ordinary power generation equipment highly susceptible to corrosion and failure.

- Poor Adaptability to Low Pressure/Calorific Value: As extraction progresses, well pressure declines. Traditional equipment cannot operate stably under low pressure (<5kPa) or low calorific value (<5500kcal/m³) conditions.

- Low Energy Efficiency: Traditional power-only generation modes utilize only 30%-40% of the fuel's energy, with a large amount of waste heat (exhaust gas at 550-600℃, jacket water at 80-90℃) being directly discharged into the atmosphere.

2.2 JingTao Energy's Solution Requirements

Addressing the above challenges, JingTao Energy has built a gas utilization system adapted to extreme operating conditions, with core requirements including:

- High Adaptability: Capable of adapting to complex gas components with high sulfur, low pressure, and low calorific value.

- Combined Heat and Power (CHP): Achieving cascaded energy utilization and increasing comprehensive thermal efficiency to over 85%.

- Intelligence & Unmanned Operation: Supporting remote monitoring and automatic start/stop, adapting to the unattended needs of well sites.

- Safety: Equipped with comprehensive explosion-proof and desulfurization capabilities to ensure intrinsic safety.

3. Core Technical Principles

3.1 System Architecture and Working Principle

The JingTao Energy wellhead gas utilization system mainly consists of four modules: the **Gas Pre-treatment Unit, Gas Power**

Generation Unit, Waste Heat Recovery Unit, and **Intelligent Control Unit**.

- Gas Pre-treatment: For high-sulfur gas fields (H_2S > 200mg/Nm^3), the system comes standard with dry/wet desulfurization devices; for water-containing gas, gas-water separation membrane technology is configured to ensure clean gas enters the engine.

- Gas Power Generation: Utilizing gas engines with lean-burn technology, the chemical energy of natural gas is converted into mechanical energy to drive an AC generator, outputting high-quality electrical power (380V/600V/690V).

- Combined Heat and Power (CHP): Through waste heat recovery devices, the system captures heat from engine exhaust (550-600℃) and jacket cooling water (80-90℃) to produce hot water (85-90℃) or steam for well site heating, crude oil heating, or process heat tracing.

3.2 Key Technical Innovations

- Wide-Range Adaptive Combustion Technology: Optimized combustion chamber design and intake supercharging systems allow the unit to operate stably within a wide range of methane content ⩾ 55% and intake pressure of 3-100kPa, making it especially suitable for low-pressure gas fields with fluctuating pressure.

- Sulfide Corrosion Resistance Technology: For high-sulfur environments, internal engine components use special anti-corrosion coatings and corrosion-resistant materials (such as nickel-based alloys), combined with front-end desulfurization systems, to ensure long-cycle operation under harsh gas conditions.

- Full-Condition Intelligent Control: A PLC-based fully automatic

control system monitors parameters such as gas pressure, temperature, voltage, and frequency in real-time, featuring fault self-diagnosis, automatic alarming, and remote restart capabilities.

4. System Configuration and Key Specifications

Fig. 4-1: Integrated Power Generation System for Drilling Rigs – Multi-unit Parallel Operation in Oilfield Conditions.

4.1 Hardware Configuration

- Core Power: Equipped with high-performance gas engines, with displacements ranging from 8.6L to 50L, adapting to different gas volume scales.

- Generator: High-efficiency AC synchronous generator, protection class IP23, insulation class H.

- Waste Heat Recovery System: Integrated heat exchange module capable of producing both domestic hot water and process heat simultaneously.

- Electrical System: Equipped with GGD-type AC low-voltage distribution cabinets and intelligent circuit breakers, supporting parallel operation and grid synchronization ("four-remote" functions).

- Protection Class: Outdoor units adopt soundproof enclosures or containerized designs, with a protection class of IP54 or above, adapting to harsh environments such as deserts, plateaus, and coastal areas.

Fig. 4-2 Associated Gas Power Generation at Pumping Unit Sites – Turning Wasted Gas into Electricity.

4.2 Key Performance Indicators

Parameter	Specification
Output Power Range	100 kW – 1000 kW (Single Unit)
Gas Adaptability	Methane content ⩾55%; H_2S < 200mg/Nm³ (after desulfurization); Calorific Value ⩾5500 kcal/m³
Intake Pressure Range	3 kPa – 100 kPa (No additional booster/depressor required)
Comprehensive Thermal Efficiency	⩾ 85% (CHP Mode)
Emission Standards	Compliant with Euro III/EPA standards; CO_2 emission reduction rate approx. 60%
Control Method	Fully automatic operation + Remote 4G/5G monitoring + Cloud platform data analysis
Starting Method	DC24V Electric pre-lubrication + Automatic start

5. Typical Applications and Verified Benefits

5.1 Typical Application Scenarios

- Oilfield Associated Gas CHP: Utilizing associated gas by-products from oil extraction to generate power for pumping units and water injection pumps, while using waste heat for well site heating or crude oil dehydration heating. This solves issues of "gas shortages" or unstable grid power, achieving energy self-sufficiency.

- Self-Powered Natural Gas Gathering Stations: At natural gas gathering stations, using wellhead natural gas to drive compressors and power station equipment, significantly reducing operating costs.

- Coalbed Methane / Biogas Power Generation: Suitable for coalbed methane development in Shanxi, Inner Mongolia, etc., as well as biogas utilization in large-scale farms, converting originally vented greenhouse gases into economic benefits.

5.2 Verified Benefit Analysis

- Significant Economic Benefits:

  ◆ Diesel Substitution: In drilling platform "Gas-for-Oil" projects, fuel costs are reduced by approximately 60%-70% compared to diesel generators.

  ◆ Waste Heat Value: Through CHP, each 1000kW unit can save substantial coal or natural gas boiler heating costs annually.

  ◆ Case Data: In an associated gas project in Inner Mongolia (1500kW installed capacity), annual power generation exceeded 10 million kWh, simultaneously meeting the heat load demands of surrounding well areas, with annual comprehensive operational cost savings exceeding tens of millions of RMB.

- Environmental and Social Benefits:

  ◆ Emission Reduction: Utilizing 10,000 cubic meters of associated gas for power generation reduces CO_2 emissions by approximately 20 tons and reduces direct methane emissions (methane's greenhouse effect is 25 times that of CO_2).

  ◆ Safety: Eliminates fire and explosion hazards caused by direct venting or flaring of associated gas.

  ◆ Digital Empowerment: The remote monitoring system supports integration into the JingTao Energy Digital Oilfield Platform, enabling real-time collection of power generation data and AI energy efficiency analysis, aiding intelligent oilfield management.

6. System Integration and Digital Enablement

JingTao Energy's gas utilization system is not an isolated power generation device but an important node in the **Digital Oilfield Energy Internet**.

- Remote Monitoring: Through 4G/5G communication modules, unit data such as voltage, current, power, gas pressure, and exhaust temperature are uploaded to the cloud in real-time. Maintenance personnel can check equipment status at any time via mobile apps or computers, achieving "unattended or minimally attended" operation.

- Intelligent Dispatch: The system supports grid synchronization and can automatically adjust power generation load based on grid frequency to ensure power supply safety.

- Collaborative Operation: This system can be seamlessly integrated with JingTao Energy's Intelligent Pumping Unit System (SRM motors) and Electromagnetic Wax Prevention System, forming a full-chain green solution from "energy extraction" to "energy utilization" and "process optimization."

7. Conclusion and Outlook

JingTao Energy's Wellhead Gas / Associated Gas Integrated Energy Utilization System successfully resolves the dual contradiction of "venting waste" and "energy shortage" in oil and gas field production through advanced gas engine technology and CHP processes. Its excellent adaptability under extreme conditions such as **high sulfur and low pressure**, along with a comprehensive energy utilization rate of up to **85%**, not only creates significant economic value for customers but also contributes a practical and feasible technical path to achieving "Carbon Peaking and Carbon Neutrality" goals.

In the future, JingTao Energy will continue to deeply cultivate the field of oil and gas field energy recycling, promoting the deep integration of gas power generation technology and renewable energy, providing global customers with smarter, greener, and more efficient industrial power solutions.

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